

# Evaluating the use of Aeolus satellite observations in Harmonie-Arome

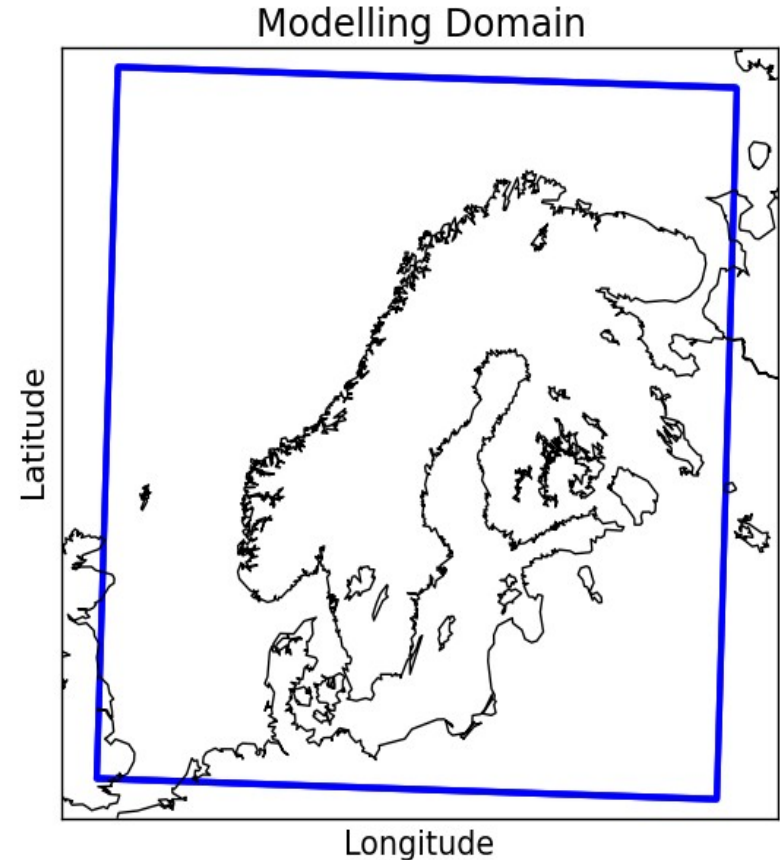
The background of the slide features a satellite in orbit above the Earth. A large, curved, semi-transparent blue and green grid is overlaid on the Earth's surface, representing a wind field or atmospheric model. White arrows of varying lengths and directions are scattered across the grid and the Earth's surface, indicating wind vectors. The satellite is positioned in the upper right corner, with a purple beam of light directed towards the Earth's surface.

Susanna Hagelin

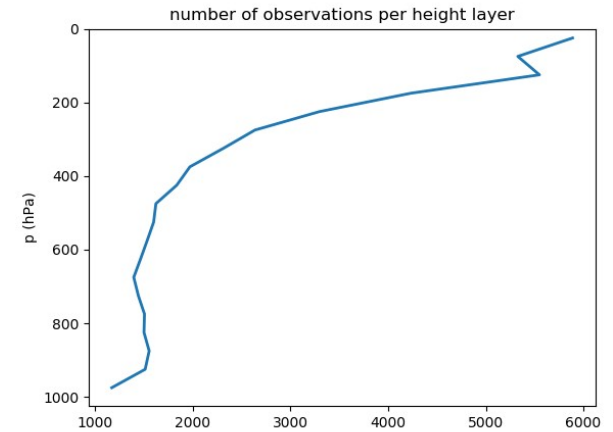
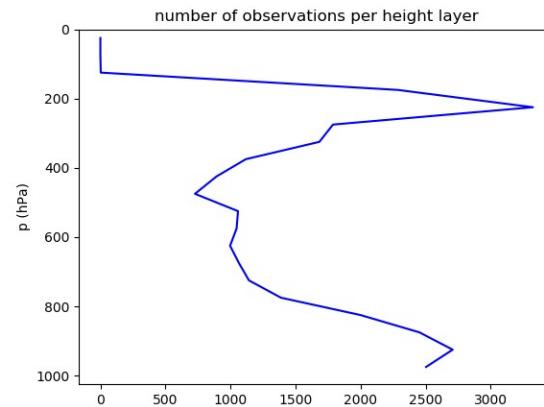
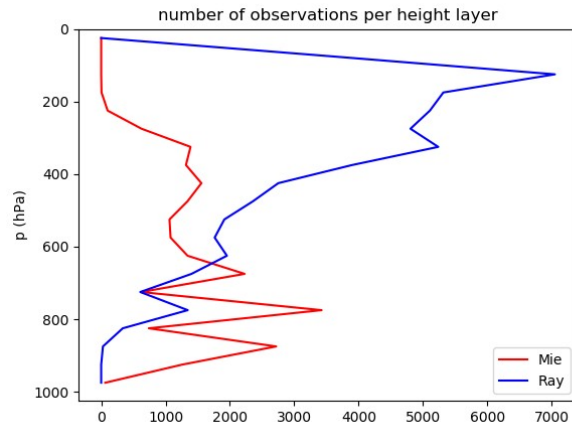
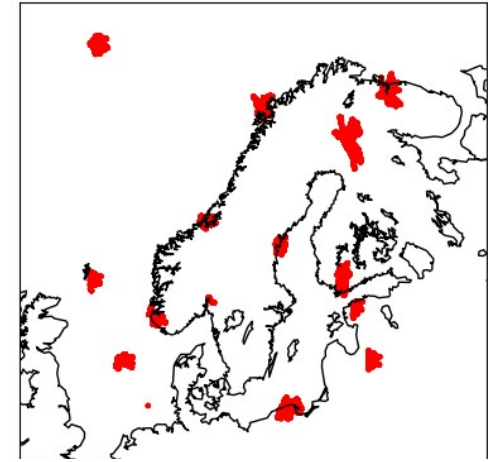
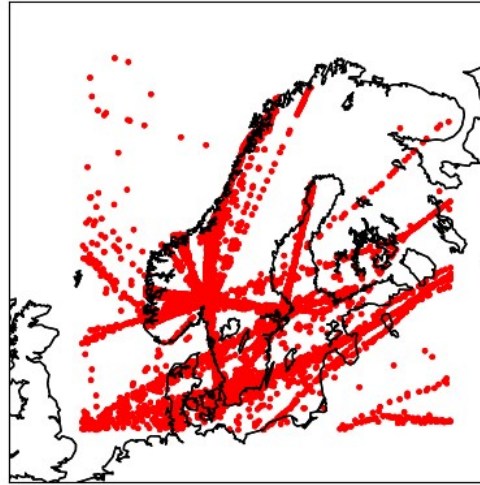
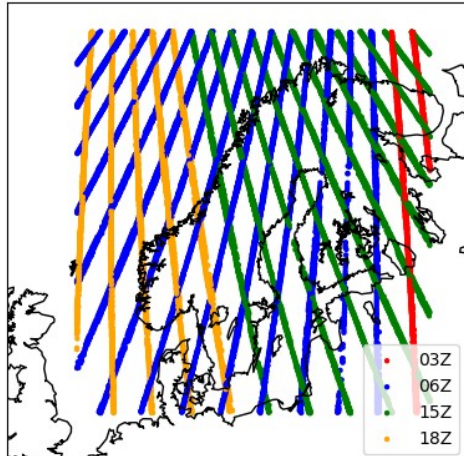
**SMHI**

# HARMONIE-AROME NWP configuration

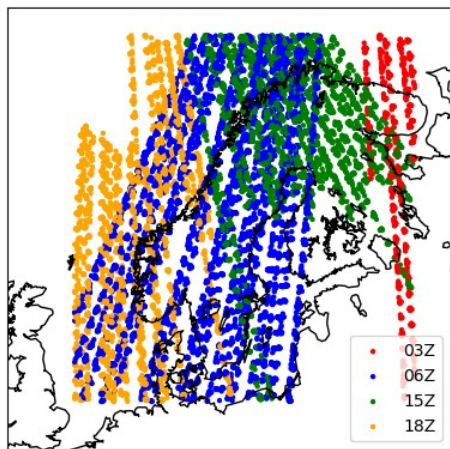
- MetCoOp is a non-hydrostatic forecast model.
- 2.5 km grid size and 65 vertical levels. (960 x 600 x 65 points)
- Initial and boundary conditions from ECMWF IFS
- 3D-Var data assimilation with 3h DA cycle.
- Assimilated obs:
  - Conventional observations
  - AMSU-A and MHS satellite radiances
  - Aeolus HLOS (Horizontal Line Of Sight) L2B winds from the ALADIN Doppler wind lidar which gives a vertical wind speed profile
- Two experiment periods: 14 Sep to 15 Oct 2018 (laser A data) and 20 April to 19 May 2020 (laser B data, with M1 temperature bias corrected, see slide 5)
- Set of 4 experiments run for each period
  - No Aeolus data
  - All Aeolus data
  - Only Rayleigh data (clear sky, lower resolution)
  - Only Mie data (cloudy sky, higher resolution)



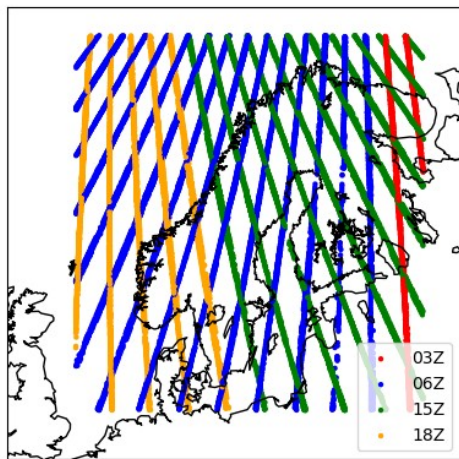
# Available upper air data (laser B period) (**Aeolus**, **aircraft**, **radiosonde**)



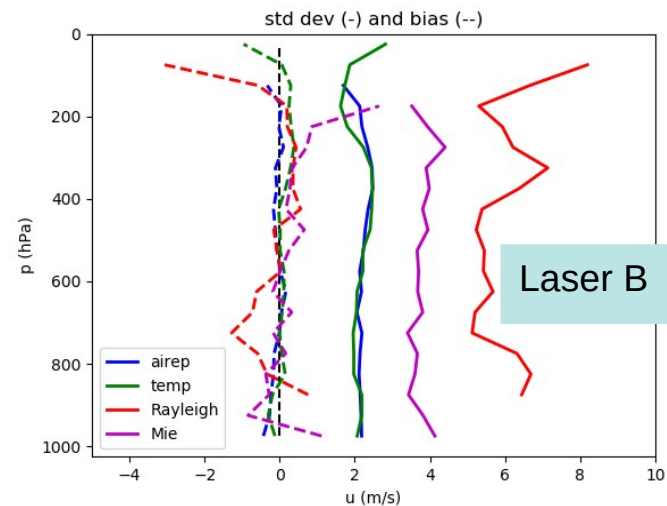
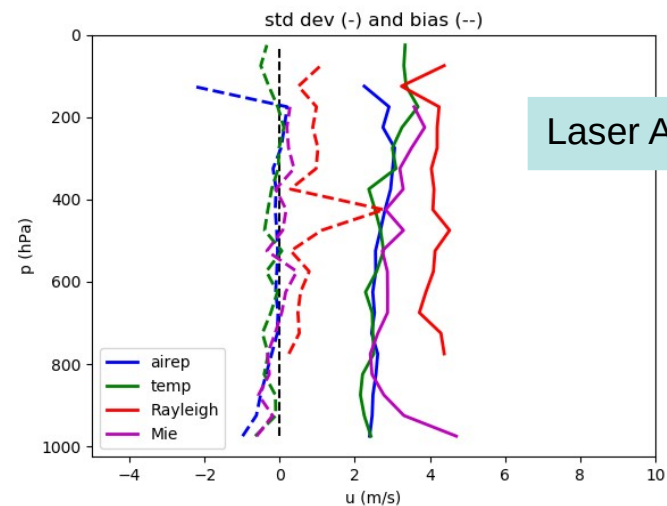
# Data availability and quality



Aeolus coverage during laser A period (top) and laser B period (bottom)  
- Usually two or three overpasses per day.

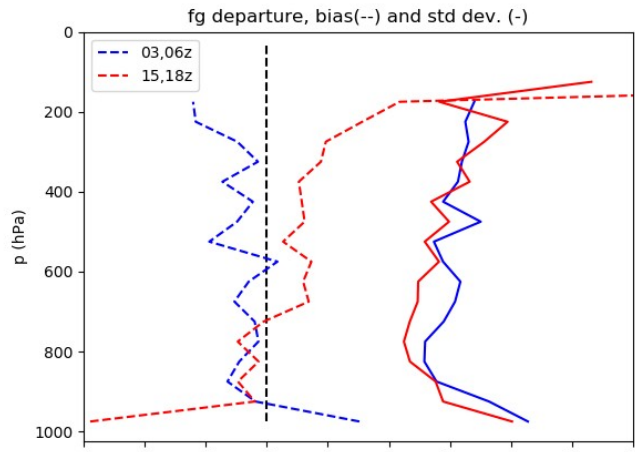


Comparing Aeolus STDV of O-B (observation minus background) to **radiosondes** and **aircraft** data  
- Laser A: **Mie** similar quality to RS and aircraft, **Rayleigh** somewhat worse  
- Laser B: Aeolus quality degraded



# Separating ascending and descending orbits

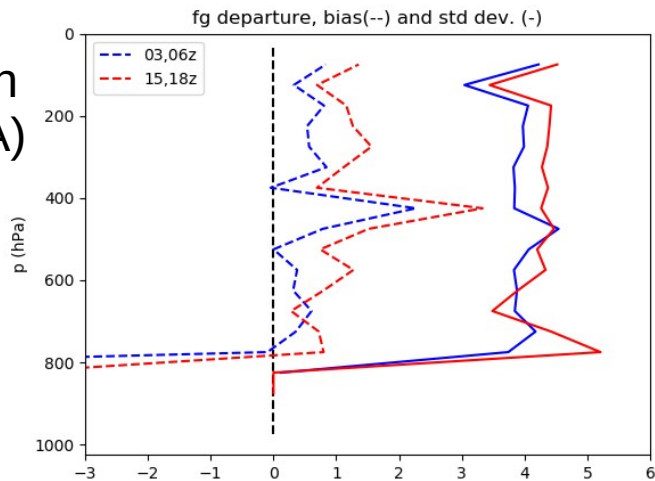
Mie  
(Laser A)



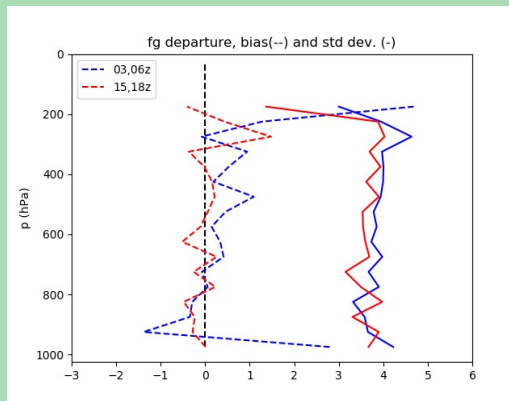
- Over MetCoOp domain, 03 and 06 UTC orbits are descending and 15 and 18 UTC are ascending
- O-B statistics - smaller bias for descending orbits, std dev. opposite trends for Mie and Rayleigh data

M1 mirror temperature bias correction available

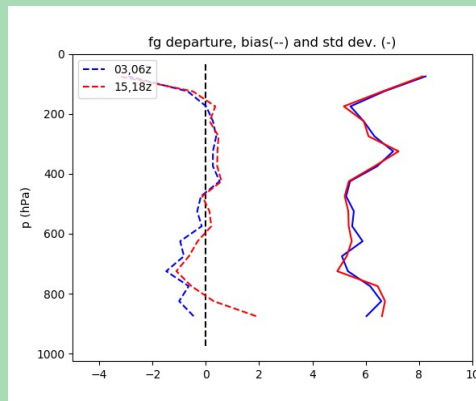
Rayleigh  
(Laser A)



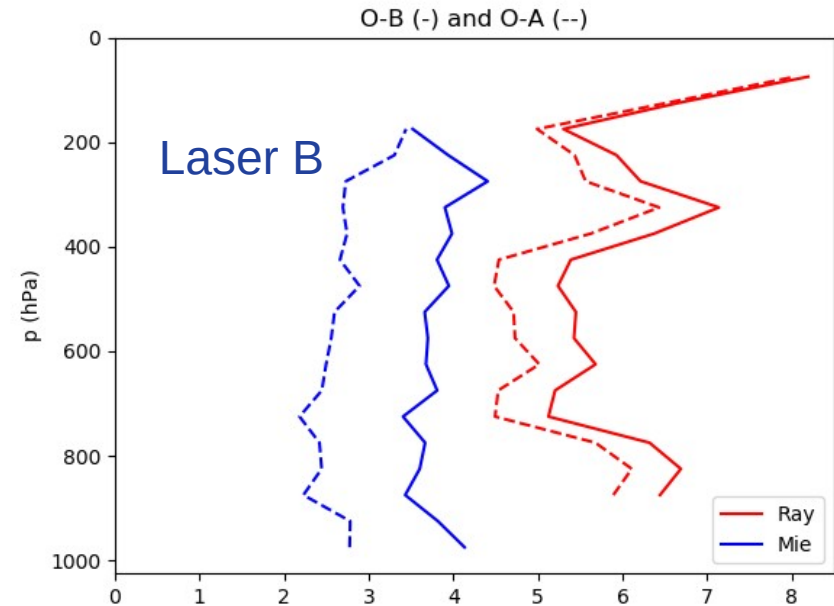
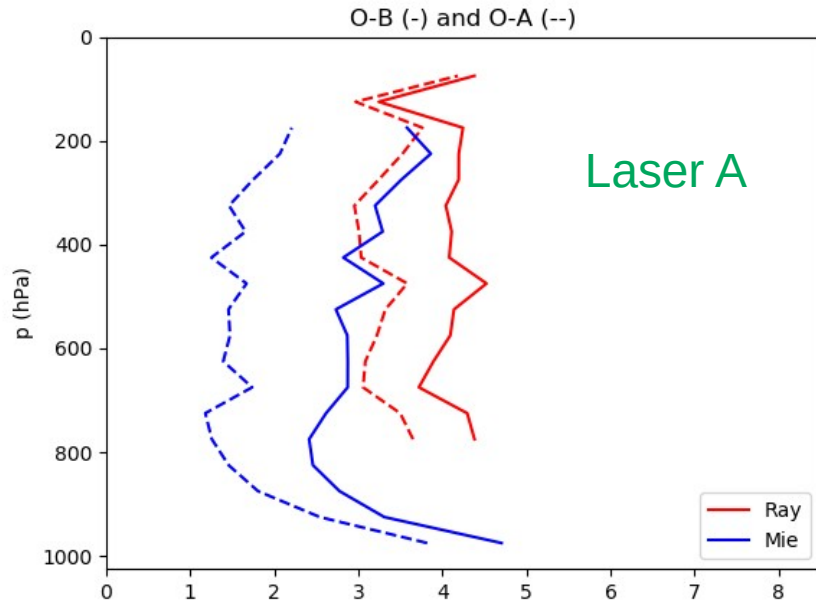
Mie (Laser B)



Rayleigh (Laser B)



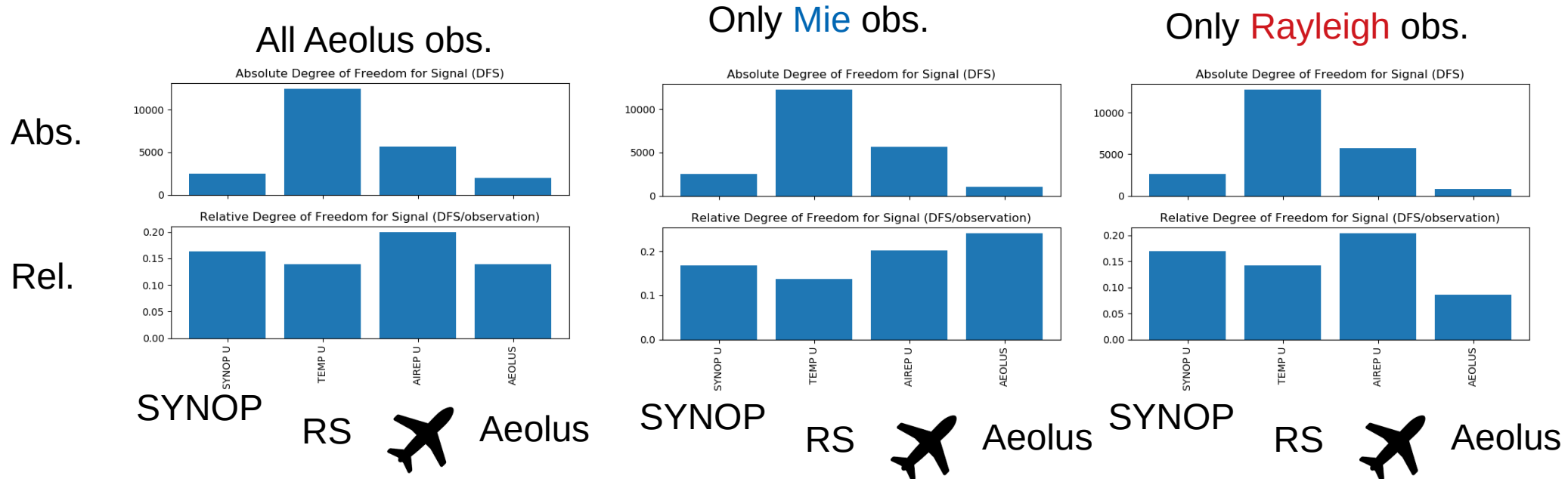
Do the Aeolus observations change the model results?  
or  
What's the difference between Aeolus Observations and model  
Background and Analysis?



# Impact on modelling system - Degrees of Freedom of Signal (DFS)

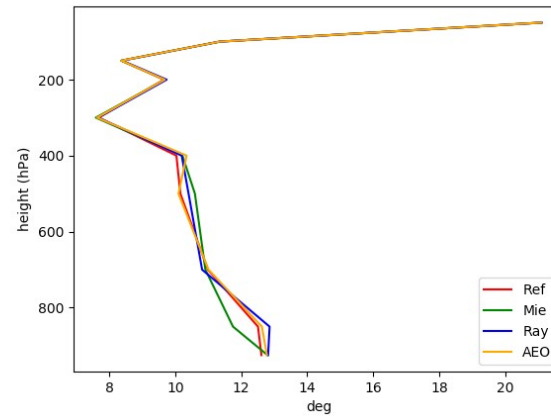
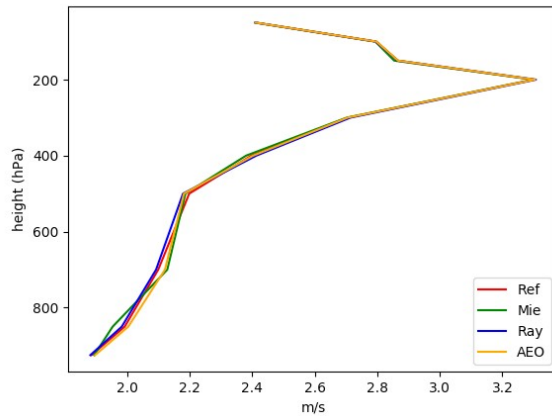
Laser B

- Figures show the impact different types of observations of the wind speed, but not whether the impact is good or bad
- Synop stations (hourly), radiosondes (twice per day), aircraft (mostly daytime) and Aeolus (03, 06, 15 and 18 UTC)
- All model cycles used here

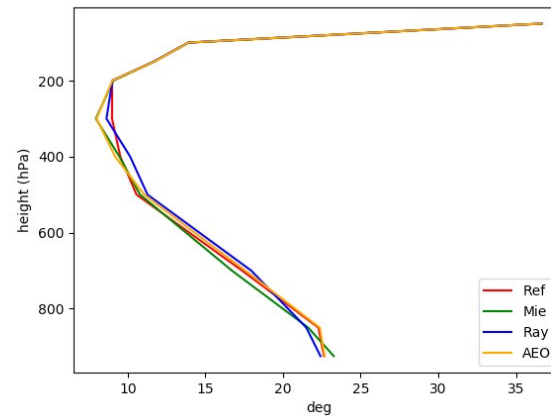
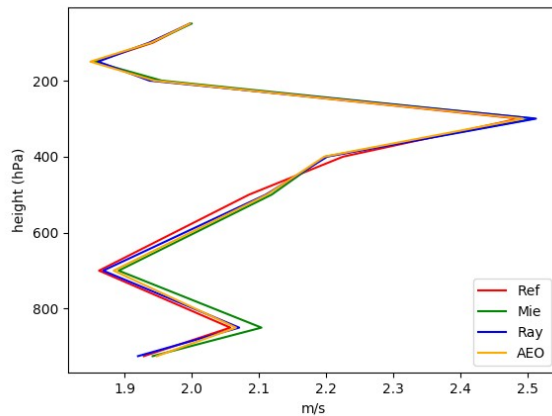


# Verification against radiosondes (fc +6h)

Laser A – wind  
speed and  
direction STDV



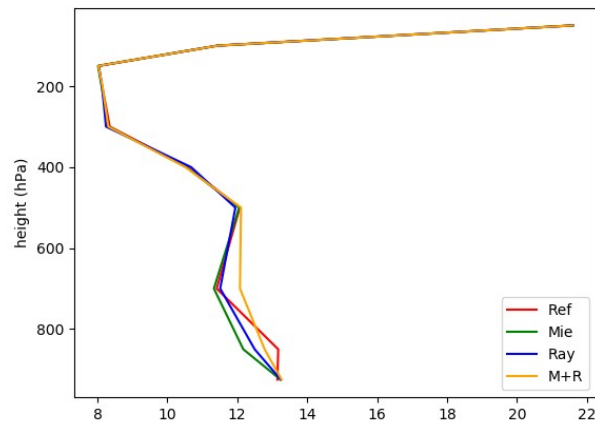
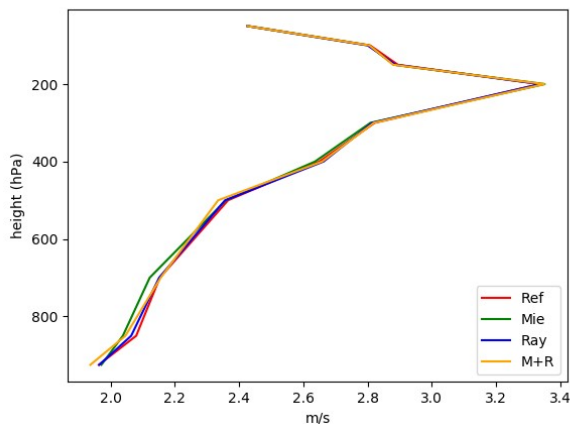
Laser B – wind  
speed and  
direction STDV



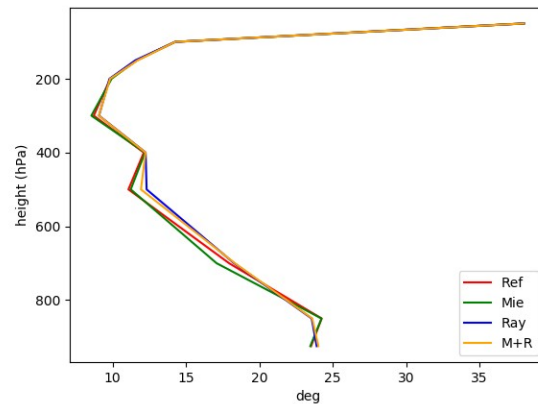
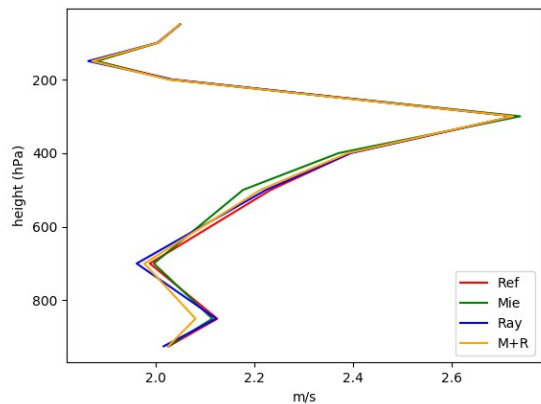
Cntr  
Mie only  
Ray only  
Mie and  
Rayleigh

# Verification against radiosondes (fc +12h)

Laser A – wind  
speed and  
direction STDV

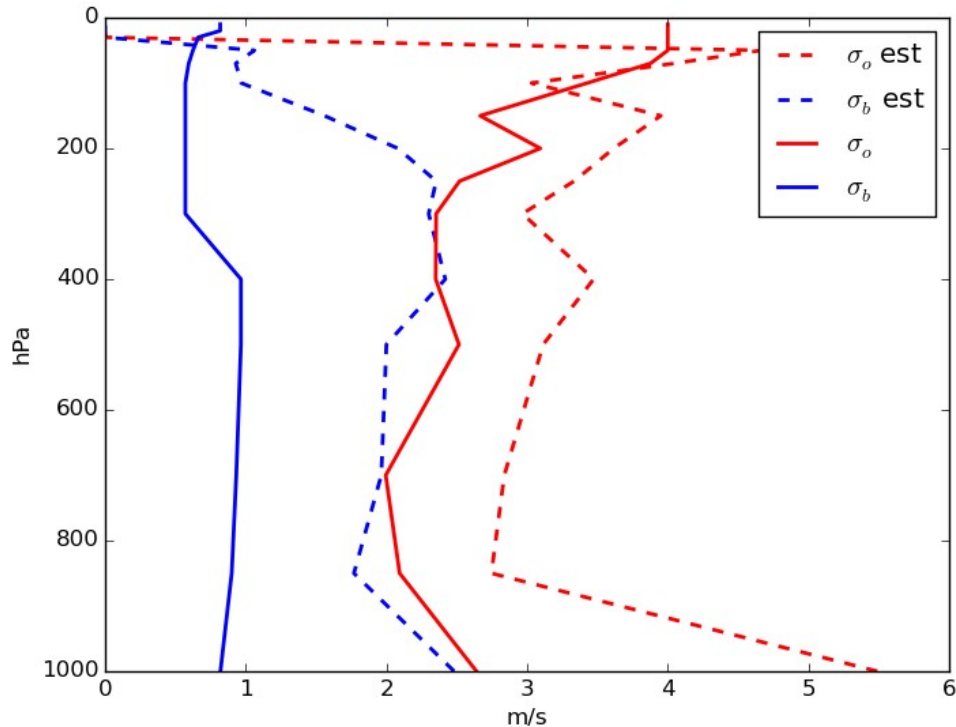


Laser B – wind  
speed and  
direction STDV



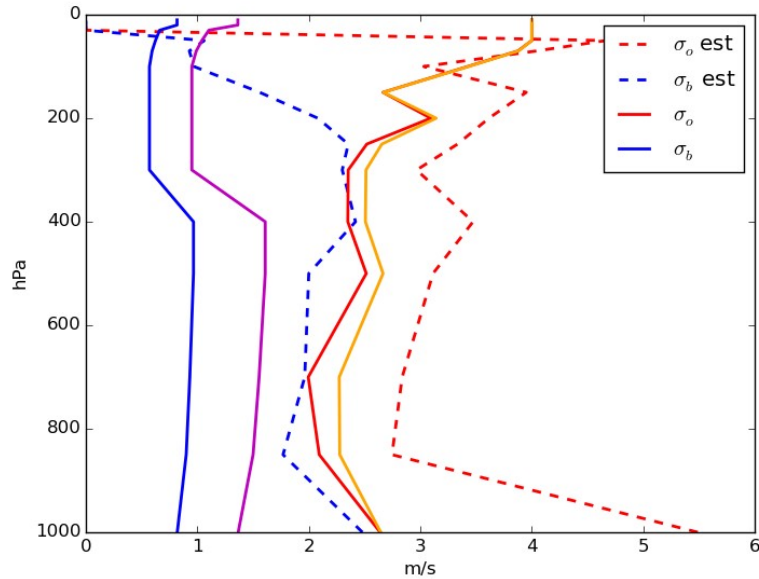
Cntr  
Mie only  
Ray only  
Mie and  
Rayleigh

# Desroziers diagnostics (laser A period)

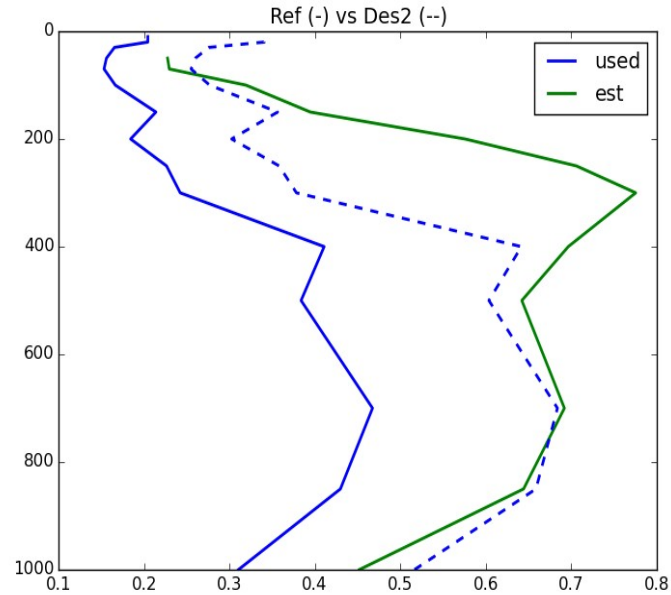


- Observation (red) and background (blue) errors used by the model (solid lines)
- Observation and background errors recommended by the Desroziers diagnostics (dashed lines, same colours)
- Result: Desroziers diagnostics recommends increasing errors for both model and observations, but with a larger error increase for model so the observations are given more weight.

## Background and observation errors



## Background and observation error ratio

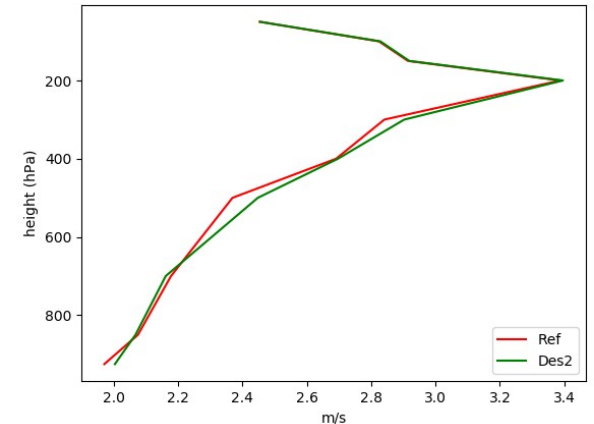
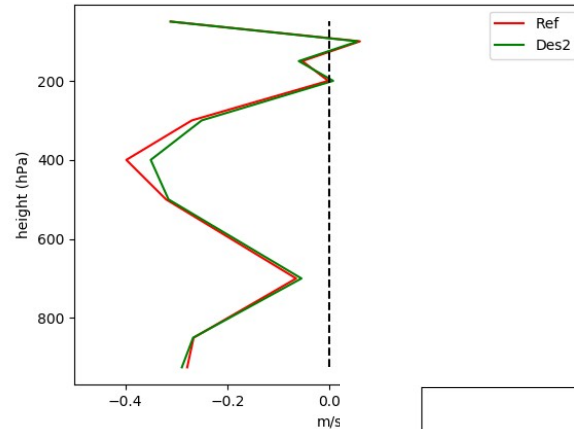


Old used values (red and blue solid lines), recommended values (red and blue dashed lines)  
New settings – Background error (purple) increased by fixed amount, Observation error (orange) – limit lower observation error allowed in Aeolus data, if observation error < 1.5 m/s, set observation error = 1.5 m/s  
New values not exactly as recommended but ratio between observation and background error is close to the recommended value (blue dashed line and green solid line)

# Verification of tuned experiment (Des2 vs Ref)

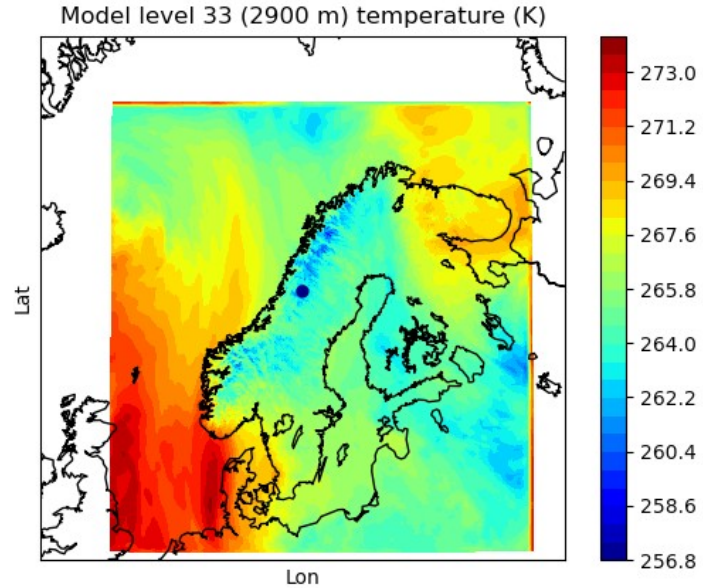
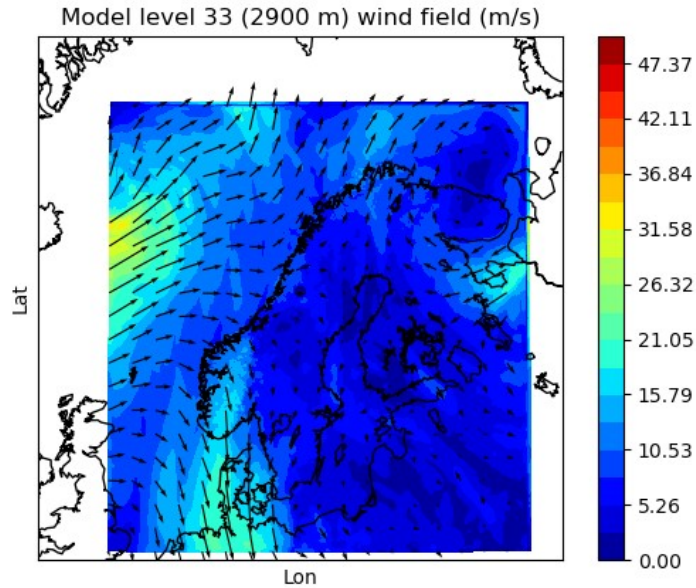
- Tuning the observation and background errors improves temperature and wind bias
- Other scores neutral or worse
- The surface parameters all get worse with the tuned settings
- Some more tuning still to do
  
- Other tests experimenting with removing large scale mixing (model is less dependent on LBCs) also worsen the performance

Bias and RMSE of wind speed



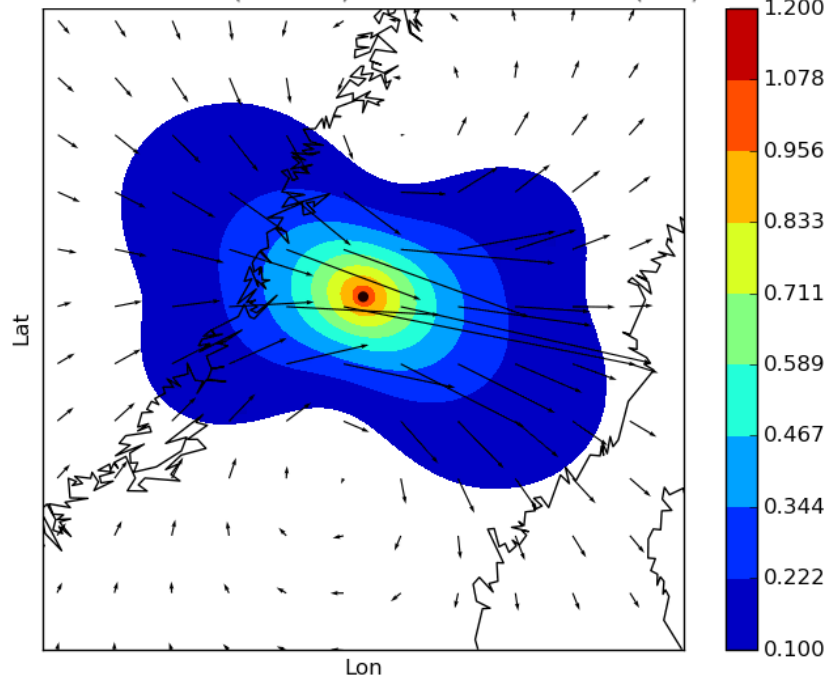
# 4D-Var – single obs test

- A single Mie observation is added to a Harmonie-Arome simulations using either 3D-Var or 4D-Var data assimilation
- - 7 m/s HLOS (Horizontal Line Of Sight) wind valid at 20200526 06.50 UTC

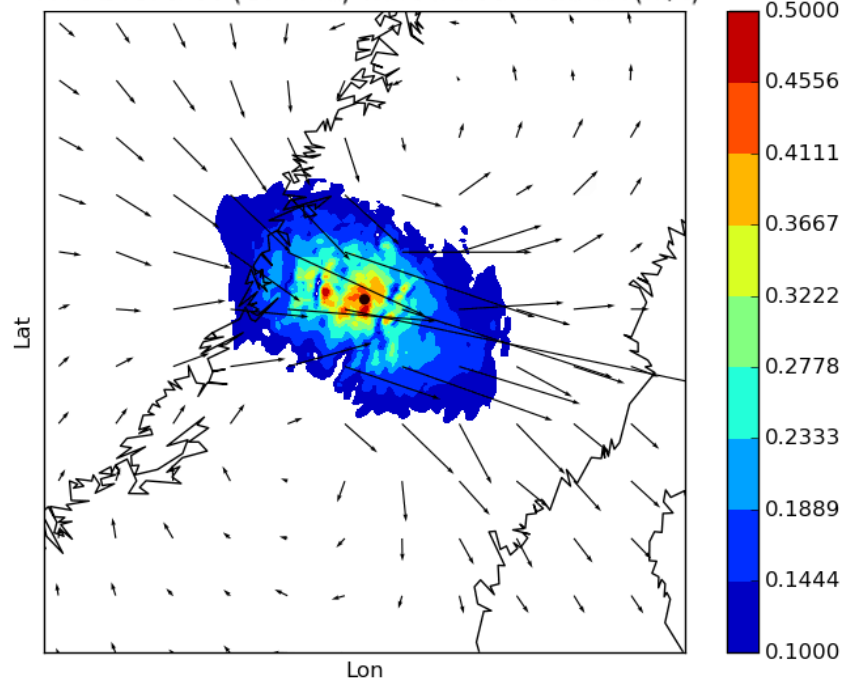


# Analysis increments of wind speed

Model level 33 (2900 m) wind field increment (m/s)



Model level 33 (2900 m) wind field increment (m/s)



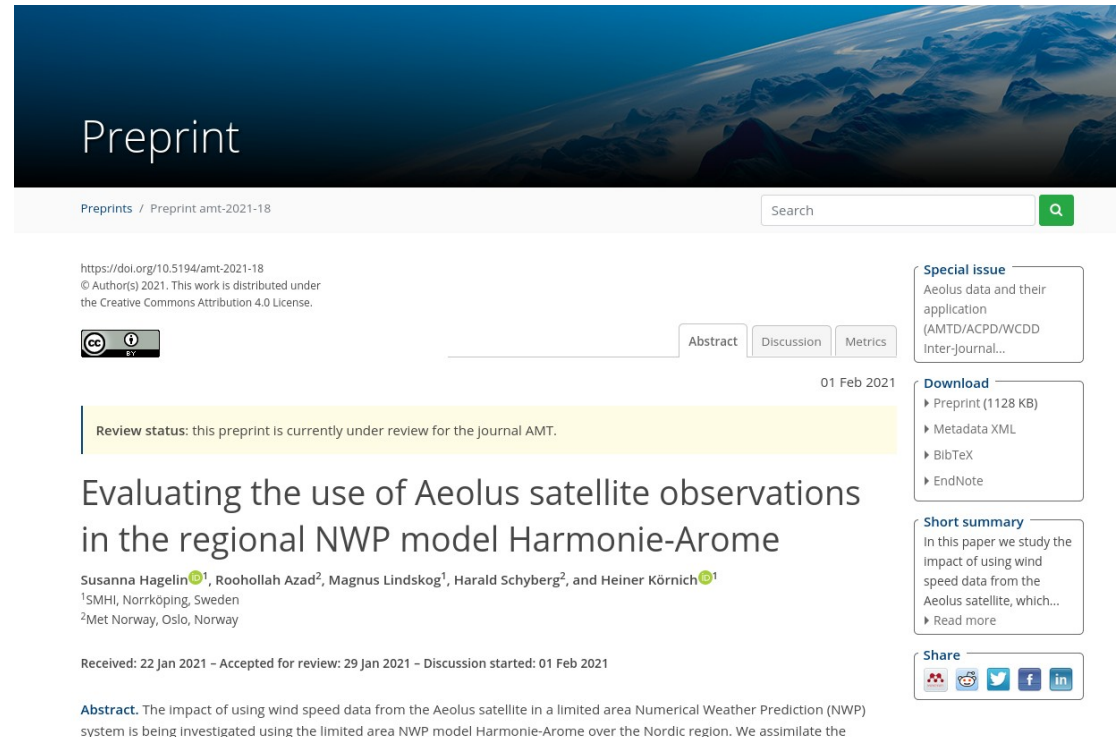
Differences due to the better handling of time information in 4D-Var and better use of model information creating flow dependent analysis increments

# Conclusions

- Aeolus data successfully used in data assimilation for Harmonie-Arome in 3D-Var
- Laser A period
  - most impact on analysis from using Mie data, impact in analysis also seen with Rayleigh data
  - neutral forecast scores
- Laser B period
  - similar results in analysis and verification scores
  - larger observation errors
- 4D-Var shows promising result

For more details, see

<https://doi.org/10.5194/amt-2021-18>



The screenshot shows a preprint page with a blue header and a search bar. The main content area includes a title, authors, and a review status banner. The title is "Evaluating the use of Aeolus satellite observations in the regional NWP model Harmonie-Arome". The authors are Susanna Hagelin<sup>1</sup>, Roohollah Azad<sup>2</sup>, Magnus Lindskog<sup>1</sup>, Harald Schyberg<sup>2</sup>, and Heiner Körnich<sup>1</sup>. The review status banner indicates that the preprint is currently under review for the journal AMT. The page also features a "Special issue" section, a "Download" section with links to Preprint (1128 KB), Metadata XML, BibTeX, and EndNote, and a "Short summary" section. The "Share" section includes icons for various social media platforms.

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## Evaluating the use of Aeolus satellite observations in the regional NWP model Harmonie-Arome

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Received: 22 Jan 2021 – Accepted for review: 29 Jan 2021 – Discussion started: 01 Feb 2021

**Abstract.** The impact of using wind speed data from the Aeolus satellite in a limited area Numerical Weather Prediction (NWP) system is being investigated using the limited area NWP model Harmonie-Arome over the Nordic region. We assimilate the

**Special issue**  
Aeolus data and their application (AMTD/ACPD/WCDD Inter-Journal...)

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